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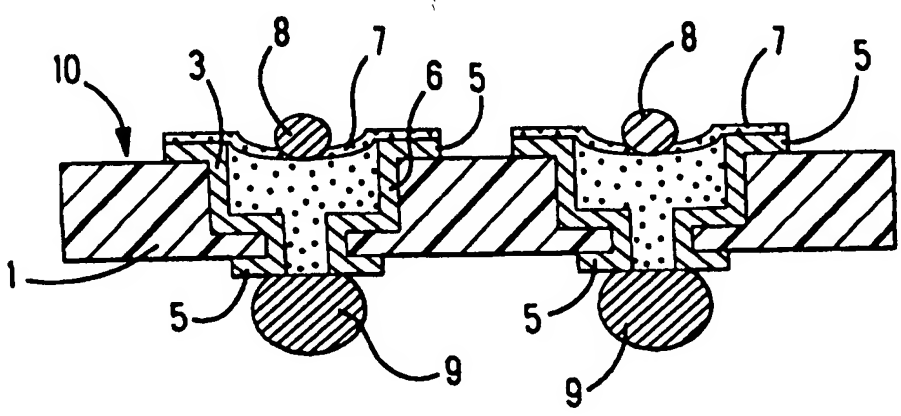

(57) Abstract

An electrical connector (10) with multiple through holes (2, 50) extending through an insulating sheet (1, 20), first conducting material lining the through holes (2, 50) and connected to conducting lands (5) on the sheet (1, 20), and deformable material (6) in the through holes (2, 50), and conducting contact members (8) on ends of the deformable material (6), and the contact members (8) deforming the deformable material (6) when pressure is applied on the contact members (8).

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CONNECTOR AND MANUFACTURING METHOD THEREFOR

FIELD OF THE INVENTION

The invention relates to an electrical connector with contact members that extend along through holes in an insulating sheet.

BACKGROUND OF THE INVENTION

A known electrical connector is disclosed in U.S. Patent 5,163,834. The known electrical connector comprises, an insulating sheet, through holes through the insulating sheet and contact members formed from elastic conductive material extending through the through holes and projecting beyond a surface of the insulating sheet to provide projecting contact members.

In the known connector, the elastic material of the projecting contact members is easily worn or broken due to weakness of the material and the lack of lateral support of the material.

The problem to be solved is to provide projecting contact members that are laterally supported, either by inherent strength of the contact members or by the contact members being defined by and laterally supported by a continuous layer of anisotropic conductive material covering the sheet.

SUMMARY OF THE INVENTION

According to the invention, an electrical connector comprises, multiple through holes extending through an insulating sheet, first conducting material lining the through holes and connected to conducting lands on the sheet, deformable material in the through holes, and conducting contact members supported on the deformable material, the conducting contact members extending beyond the insulating sheet and the conducting lands. An advantage of the invention resides in the conducting contact members being laterally self supporting or laterally supported by additional material covering the insulating sheet and the conducting lands. Additionally, the electrical connector according to the invention comprises an insulating sheet that can be used to connect a circuit board surface to ball grid arrays and land grid arrays with a removable connection. Additionally, the electrical

connector according to the invention comprises an insulating sheet that can be used to connect a circuit board surface to another circuit board surface to provide an multiple layer circuit board.

According to one embodiment, the deformable material is conductive, advantageously to provide a deformable through hole connection through the insulating sheet.

According to another embodiment, the deformable material is anisotropic conductive, and the conducting contact members are defined by and are laterally supported by anisotropic conductive material covering the sheet and the conducting lands.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings, according to which:

DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a cross section view of an insulating sheet with one of multiple through holes extending through the insulating sheet;

FIGURE 2 is a view similar to Fig. 1, illustrating each through hole with conducting material lining the through hole and connected to conducting lands on the insulating sheet;

FIGURE 3 is a view similar the Fig. 2 illustrating each through hole with conductive material in the through hole;

FIGURE 4 is a view similar to Fig. 3 illustrating conductive contact members on ends of the conductive material in the through hole;

FIGURE 5 is a view similar to Fig. 4 illustrating conductive adhesive on the conducting lands;

FIGURE 6 is a view similar to Fig. 3 illustrating conductive contact members engaging the conductive lands;

FIGURE 7 is a view similar to Fig. 5 illustrating conductive contact members smaller in diameter than the diameters of each through hole;

FIGURE 8 is a view similar to Fig. 7 illustrating solder balls on ends of the conductive material in each through hole;

FIGURE 9 is a cross section view with parts exploded of an electrical connector as shown in Fig. 10;

FIGURE 10 is a view similar to Fig. 9 of an electrical connector connecting a circuit board to another circuit board to provide a multiple layer circuit board;

FIGURE 11 is a view similar to Fig. 11 illustrating a multiple layer circuit board attached to a plate;

and FIGURE 12 is a top view of a connector as shown in Figs. 9-11.

DETAILED DESCRIPTION

With reference to Figs. 1-8 and 9-10, embodiments of an electrical connector 10 will now be described. The connector 10 comprises, an insulating sheet 1 made from a resin such as polyimide, polyester, glass epoxy, paper phenol, ceramics, polytetrafluoroethylene, silicone, etc.

For example, the sheet 1 is provided with conducting lands 5 for connection to a PGA package or LGA package, not shown, or for connection to circuit patterns 60 on a layer of a multiple layer circuit board, Figs. 9-12.

The conductive lands 5 correspond in location with pads of an LGA or BGA circuit package, and with conducting lands on a circuit board to which the circuit package is to be connected. Further, the conductive lands 5 can correspond with conducting lands 5 on a circuit board, for example, the lands 5, Figs. 9-11. The lands 5 are made, for example, by etching copper foil layers on both, opposite surfaces of the sheet 1.

With reference to Fig. 12, the sheet 1 can be in the form of a flexible film 20 with reel winding features, for example, sprocket holes 17 along both side edges of the film for feeding the film. Further for example, with reference to Figs. 9 - 12, the sheet 1 can be a 1-200 mm. thick resin layer 20 and a 5-100 mm. thick copper foil layer on both opposite surfaces, any one of the copper foil layers being selectively etched to form the conducting lands 5 and the circuit patterns 60.

For example, the sheet 1 is suitable as a layer or film 20 in a multiple layer circuit board, and can be a film or layer 20 on which the lands 5 and the circuit patterns 60 are formed, Fig. 12.

The lands 5 of the connector 10, and the circuit patterns 60, if present on the connector 10, are formed in the following process. Resist layers are applied on the copper foil layers. Then the resist layers are exposed to light, except where patterns of the resist layers cover the copper foil layers that form the lands 5 and the circuit patterns 60. The exposed resist layers are removed to reveal parts of the copper foil layers that are removed by etching, leaving remaining parts of the copper foil layers in the form of the circuit patterns 60 and the lands 5. The patterns of the resist layers are removed from the lands 5 and the circuit patterns 60.

Circuit patterns of 15-20 mm. line width and 15-20 mm. spacing apart between adjacent lines are obtained, which is about one-fourth of the sized of conventional circuit patterns.

Through holes 2, 50, having diameters smaller than the diameters of the lands 5, are provided to extend through the sheet 1 and selected lands 5 by drilling, chemical etching, stamping, laser drilling, etc. For example, through holes 2 are provided first, in the copper foil by using a ferric chloride etchant. Then a polyimide film of the resin layer sheet 20 can be etched from both surfaces with an alkali etching liquid comprising, a mixture of caustic soda, ethyl alcohol, and hydrazine.

The through holes 2, 50 are lined with conducting material 3 that connects with the lands 5 on both surfaces of the sheet 1, 20. For example, the conducting material 3 is applied by plating on the inner surfaces of the through holes 2, 50, or by applying electrically conductive resin on the inner surfaces of the through holes 2, 50, followed by heating to harden the resin. By optimizing the film material, film thickness, and etching conditions, this process is effective to obtain through holes 5, 20 of about 20 mm. in diameter which is about one-fourth of the size of plating lined holes prior to the invention.

With reference to Figs. 3 and 9, a deformable material 6 in the through holes 2, 50, closes the through holes 2, 50, after the through holes 2, 50 have been lined with the conducting material 3. The deformable material 6 is an elastic resin or elastomer hardened by heating, for example. The deformable material contains silicone as a primary material.

The conducting contact members 8, in the form of metal bodies, Figs. 4-8, connect with the ends of the deformable material 6 in the through holes 5. For example, the metal bodies comprise, spherical or semispheric shaped copper, solder or nickel plated with gold, or a metal plated with solder or tin. The metal bodies are adhesively attached by conductive adhesive 7 on the ends of the deformable material 6 in the through holes 2. With reference to Figs. 1-8, the surfaces of the sheet 1 are polished or buffed, before applying a coating of a silicone type conductive adhesive 7 on the ends of the deformable material 6 in the through holes 5. Alternatively, not shown, the film 20 may have conducting contact members 8 in the form of metal bodies to abut against the circuit pattern 60 on another film 20, the metal bodies being adhesively attached to ends of the deformable material 6 in the through holes 50.

The conducting metal contact members 8 in the form of metal bodies can directly contact the deformable material 6, while being attached by the adhesive 7, or the metal bodies can attach to the adhesive 7, and indirectly connect with the deformable material 6 with the adhesive 7 in between. With reference to Figs. 7 and 8, the conducting metal contact members 8 are smaller in diameter than diameters of the through holes 2, and the deformable material 6 is conductive. Electrically conductive particles such as silver or metal coated particles of plastic are mixed with the primary material of the deformable material 6. The primary material can be silicone, for example.

With reference to Fig. 6, the conducting metal contact members 8 engage the conducting lands 5 when the conducting metal contact members 8 deform the ends of the deformable material 6 in the through holes 2. The deformable material 6 can be a silicone or other elastic resin or elastomer. Alternatively, the deformable material 6 can be rendered conductive by conductive particles therein.

With reference to Fig. 8, the conducting contact members engage first ends of the deformable material 6 in the through holes 2, and solder balls 9 engage on opposite ends of the deformable material 6. The solder balls 9 also contact the lands

5. Further, the solder balls 9 can be reflowed by the application of heat to join the lands 5 to circuit paths 60 on a circuit board, not shown.

The deformable material 6 is deformed by the conducting contact members 8 that undergo pressure when pressed by a BGA or LGA package to establish good electrical connection with all electrical contact points on the package. The deformable material 6 in the through holes 2 is deformed different amounts by the conducting contact members 8 to compensate for irregularities in coplanarity.

With reference to Figs. 10 and 11, conducting contact members 8 in the form of anisotropic conductive material 80 connect with the ends of the deformable material 6 in the through holes 50. A layer 80 of an anisotropic conductive material is heat pressed between the connector 10 and at least one flexible film layer 20 having a circuit pattern 60 and lands 5. The connector 10 can be interposed between two flexible film layers 20 with an anisotropic conductive material layer 80 heat pressed between the connector 10 and each flexible film layer 20. The anisotropic conductive material adheres to the connector 10 and each flexible film layer 20. Lands 5 on the connector 10 are aligned with lands 5 on each flexible film layer 20. The anisotropic conductive material provides conducting contact members where the anisotropic conductive material of each layer 80 adheres to the aligned lands 5 on the connector 10 and the aligned lands 5 on each flexible film layer 20. The anisotropic conductive material, for example, has at least five to six electrically conductive particles in an elastic resin contributing to electrical connection between any two lands 5. The remaining anisotropic conductive material in each layer 80 surrounds the conducting contact members in the same layer 80 to laterally support the conducting contact members. An advantage resides in that the connector 10 provides through holes 50 that extend between internal layers 20 of a circuit board without a need to extend through all layers 20 of a multiple layer circuit board. Consequently, the layers 20 of the circuit board have a significant reduction in the number of through holes 5.

Each layer 80 may be about 20 mm thick. Although three layers 20 are shown, the number of layers 20 can be increased. and adhered by layers 80 of

anisotropic conductive material. Each layer 20 and the connector 10, Figs. 9-12, may be about 30 mm. thick. A six layer circuit board will be less than 300 mm. thick. Additionally, the connector 10 having a reeling structure 15 may be supplied by automated feeders to feed multiple films 20 from separate reels to a common location for heat pressing with anisotropic conductive material layers 80.

With reference to Fig. 11 flatness of the circuit board is attained by adhesively attaching the circuit board to a rigid plate 90 by an insulating or conductive adhesive 95. The plate 90 will dissipate heat when made of aluminum or other material having a good thermal conductivity.

The deformable material 6 is deformed by the conducting contact members 8 that undergo pressure when heat pressed to establish good electrical connections of the aligned lands 5. The deformable material 6 is deformed by the conducting contact members 8 when heat pressed to compensate for irregularities in coplanarity between the layers 20 and the connector 10.

Examples of the connector 10 are described in the disclosures of the priority documents. The disclosures of the priority documents are incorporated herein by reference.

WHAT IS CLAIMED IS:

1. An electrical connector comprising: multiple through holes (2, 50) extending through an insulating sheet (1, 20), first conducting material (3) lining the through holes (2, 50) and connected to conducting lands (5) on the sheet (1, 18), and deformable material (6) in the through holes (2, 50), further characterised by:

conducting contact members (8) supported on ends of the deformable material (6) in the through holes (2, 5), the conducting contact members (8) extending from the through holes (2, 5) and beyond both the sheet (1, 18) and the conducting lands (5), and the contact members (8) deforming the deformable material (6) in the through holes (2, 50) when pressure is applied on the contact members (8).

2. An electrical connector as recited in claim 1 wherein, the conducting contact members (8) comprise conducting metal contact members smaller in diameter than diameters of the through holes (2, 50), and the deformable material (6) is conductive.

3. An electrical connector as recited in claim 1 wherein, the conducting contact members (8) engage the conducting lands (5) when the conducting contact members (8) deform the deformable material (6) in the through holes (2, 50).

4. An electrical connector as recited in claim 1 wherein, the conducting contact members (8) engage the conducting lands (5), and the deformable material (6) is conductive.

5. An electrical connector as recited in claim 1, and further characterised by; the conducting contact members (8) engaging first ends of the deformable material (6), and solder balls (9) on opposite ends of the deformable material (6).

6. An electrical connector as recited in claim 1 wherein, the deformable material (6) is anisotropic conductive material, and the conducting contact members (8) comprise additional anisotropic conductive material (80) covering the insulating sheet (20) and the conducting lands (5).

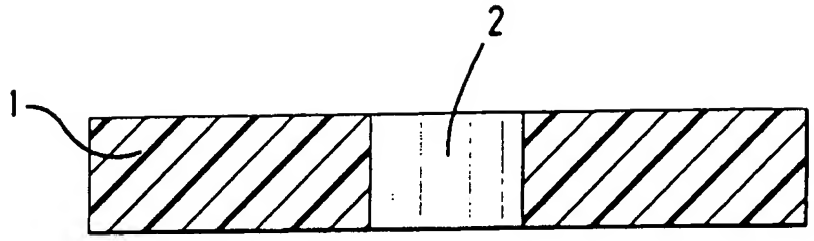

Fig. 1

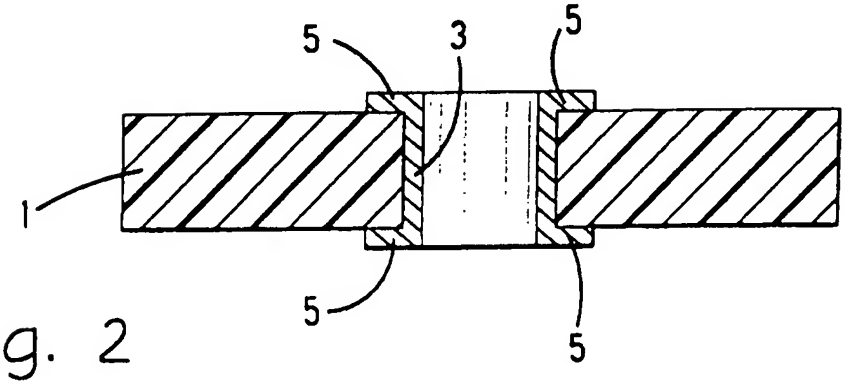

Fig. 2

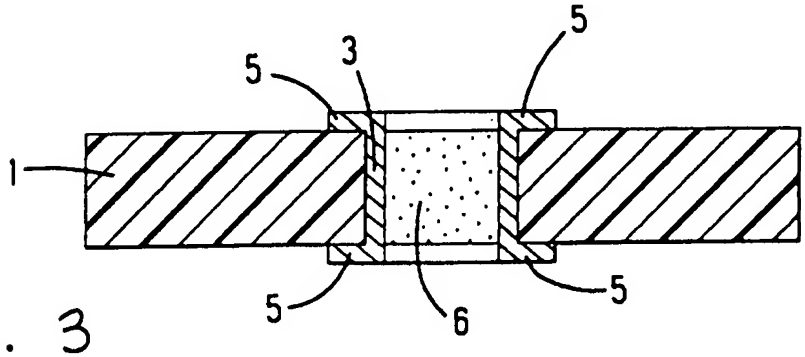

Fig. 3

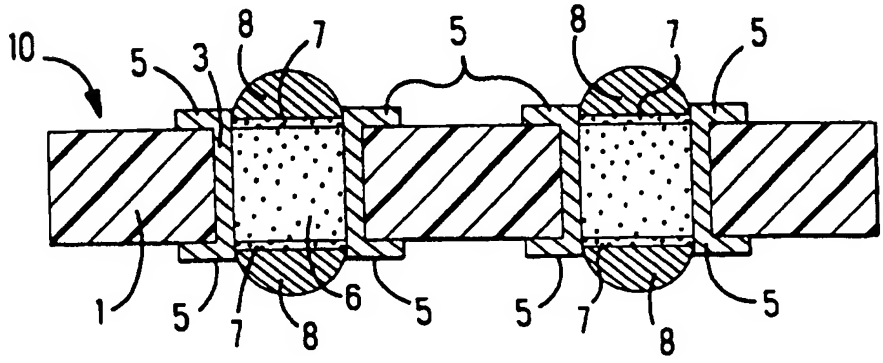

Fig. 4

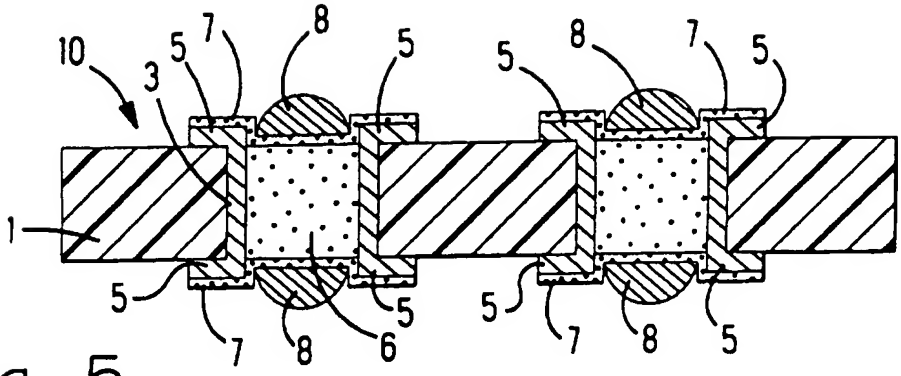

Fig. 5

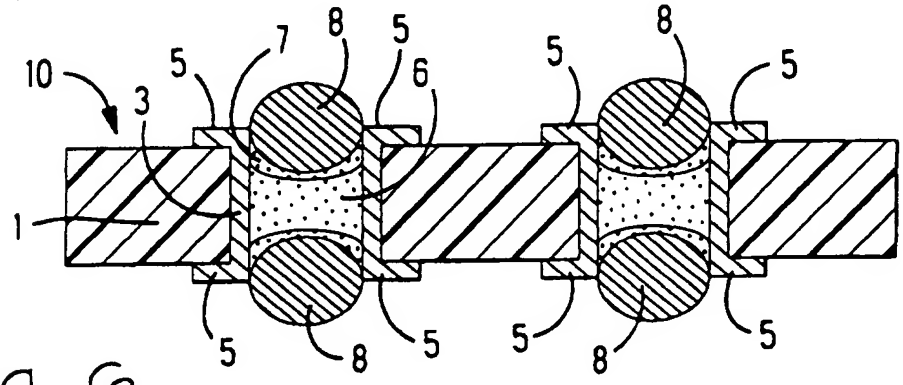

Fig. 6

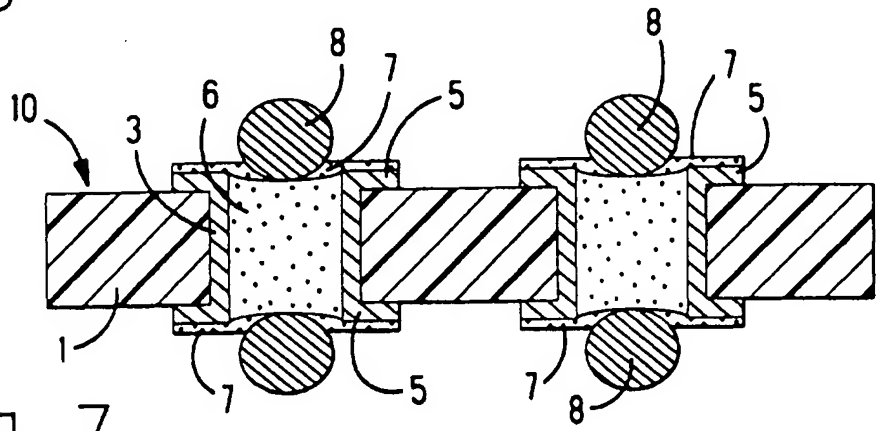

Fig. 7

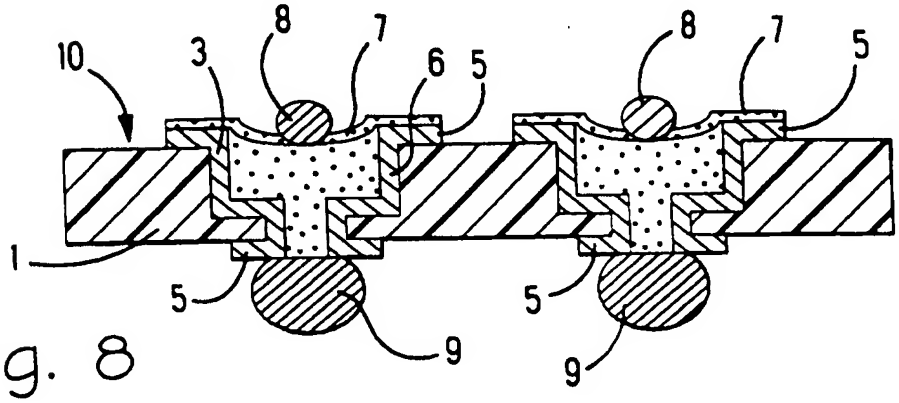

Fig. 8

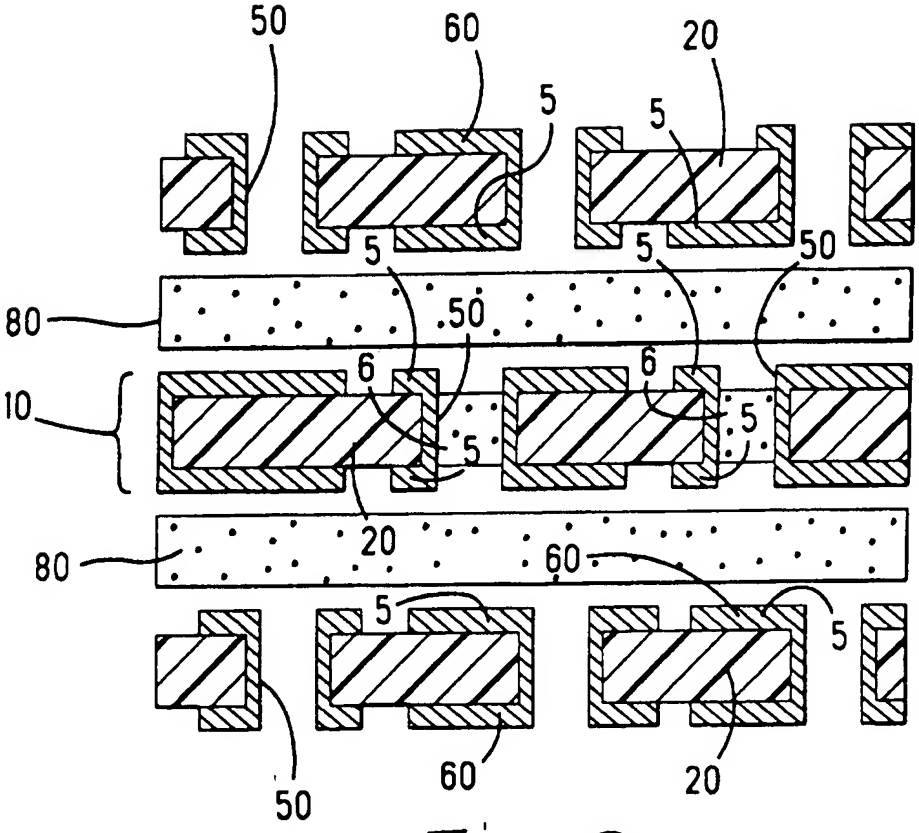
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Fig. 9

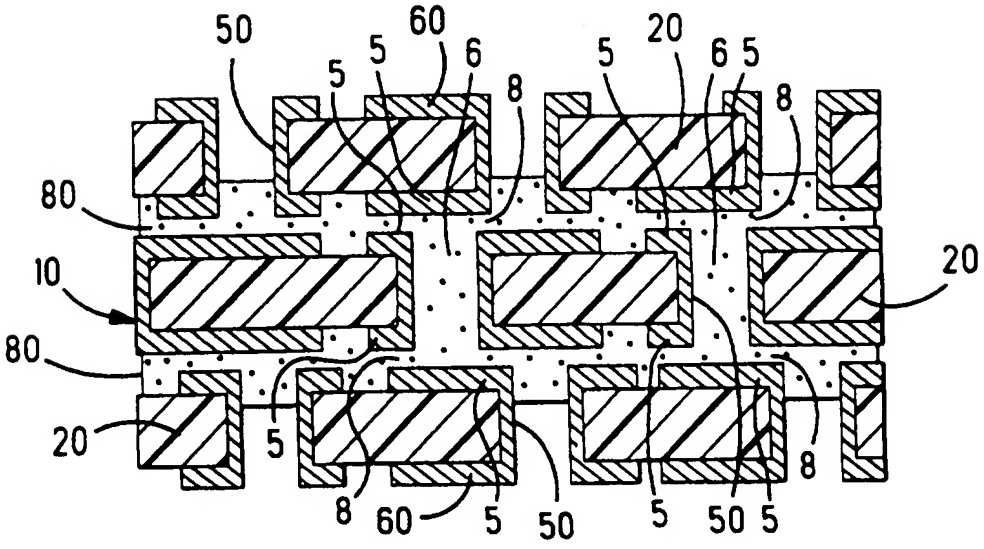
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Fig. 10

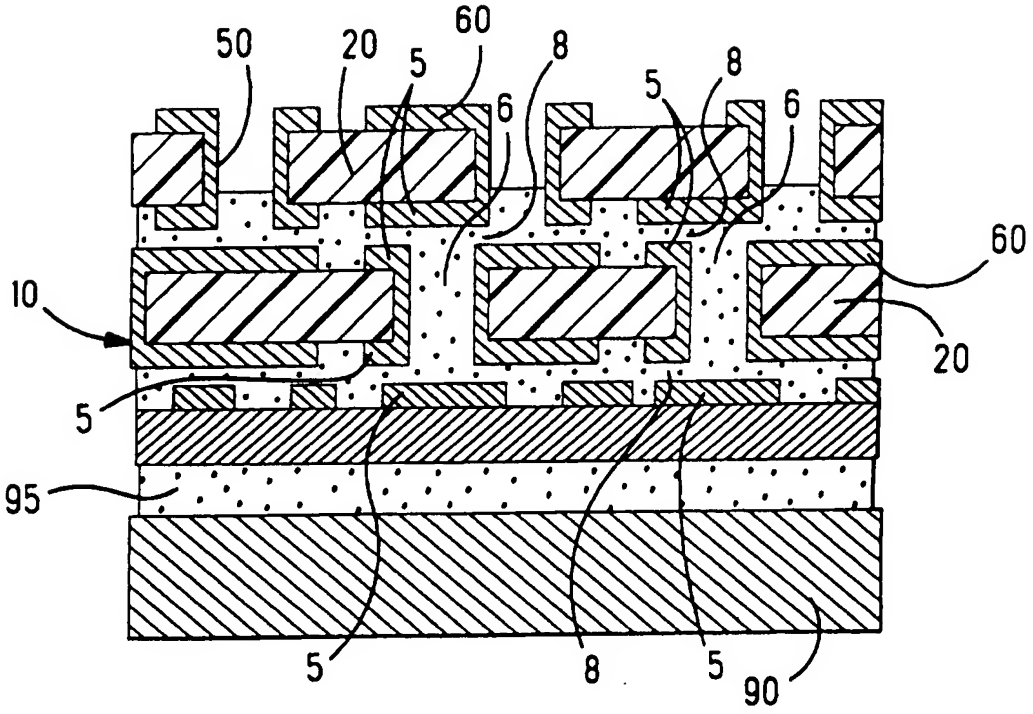

Fig. 11

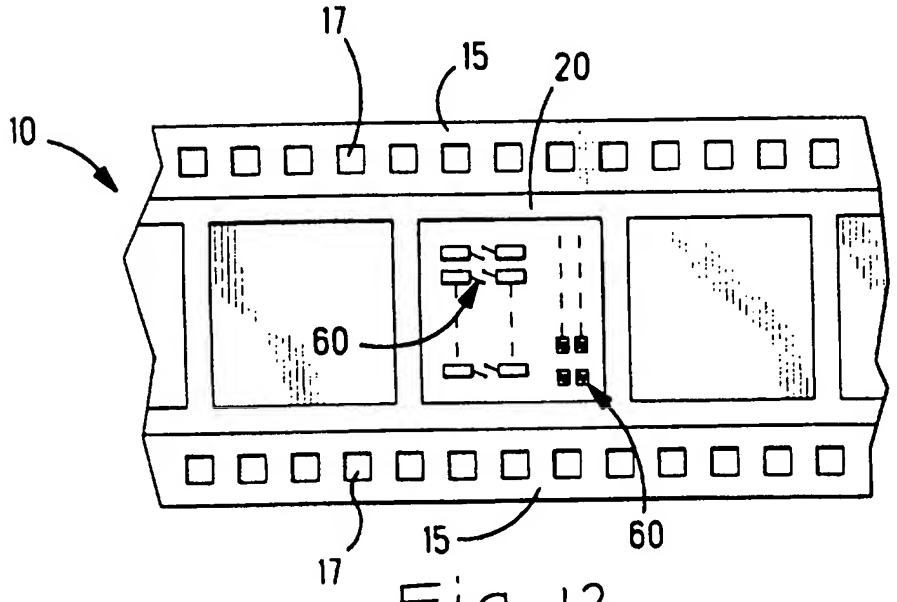

Fig. 12

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 96/16667

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H01R13/24 H01R9/09 H01R23/72

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 163 834 A (CHAPIN FLETCHER W ET AL) 17 November 1992 see claims; figures ---	1-4
Y	DE 41 13 954 A (ROGERS CORP) 31 October 1991 see claims; figures ---	1-4
A	US 5 245 751 A (LOCKE BARBARA E ET AL) 21 September 1993 see claims; figures ---	1
A	US 4 008 300 A (PONN TIMOTHY R) 15 February 1977 see claims; figures --- -/--	1

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

Interr nal Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	WO 95 34106 A (TESSERA INC) 14 December 1995 see claims; figures	1,5

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ional Application No
PCI/US 96/16667

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